

# Robotic aircraft explores clouds and global warming

**Successful ARM-UAV mission in subtropics precedes more challenging studies**

By Nancy Garcia

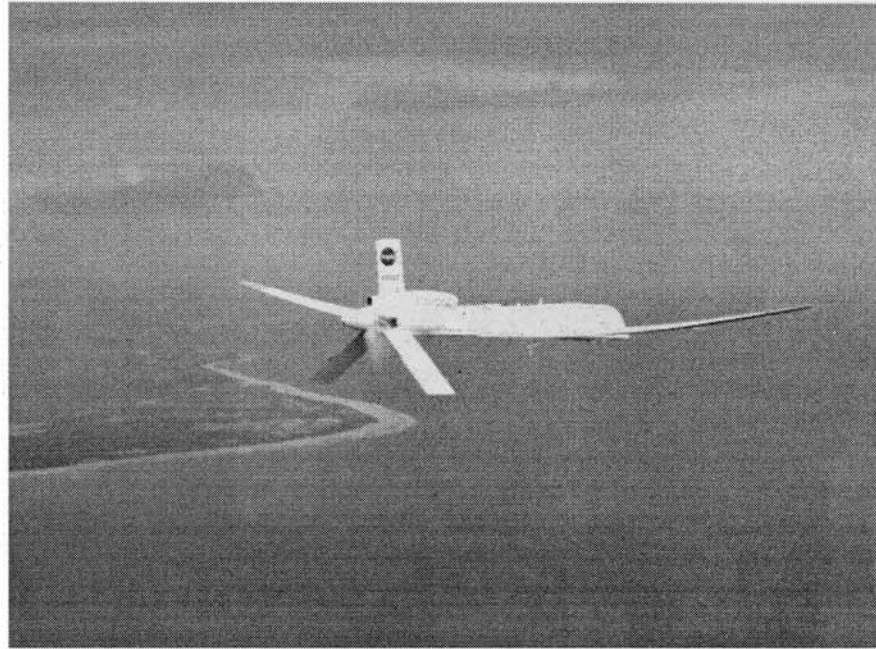
A series of scientific flights with a remotely piloted aircraft above the ocean near Kauai have probed how clouds affect global warming, serving as a warm-up act for studies in the birthplace of tropical storms.

The flights, under Sandia technical guidance, might be considered a search for the Earth's thermostat.

"The energetics of the planet are intimately coupled with water," explains Tom Ackerman, chief scientist for DOE's Atmospheric Radiation Measurement (ARM) program at Pacific Northwest National Laboratory in Richland, Wash. "People say life as we know it is controlled by water. The climate as we know it is controlled by water. . . . In the greenhouse effect, water vapor is the biggest contributor. If you want the real thermostat of the atmosphere, it's really water vapor."

Clouds have a two-fold effect on the way the sun warms the atmosphere, adds Graeme Stephens, a professor of atmospheric science at Colorado State University, who designed key field experiments for the Unmanned Aerospace Vehicle (UAV) mission. Clouds both contain some heat in the atmosphere, acting like a blanket, and reflect some solar energy back into space.

For the first time using a remotely piloted aircraft at these latitudes, these flights "started to unscramble what's going on in clouds," he says. The remotely piloted Altus aircraft, built by General Atomics Aeronautical Systems, Inc. for



THE ALTUS FLIES near the Kauai coastline during the ARM-UAV mission to study the role of clouds in global climate change. (Photo by Dick Jones, 8414)

says. "They're transparent, hard to get to, and very variable."

When it comes to creating computer models of global climate change, he adds, "clouds are one of the most uncertain effects." DOE's Atmospheric Radiation Measurement program began in 1990 to improve how climate models incorporate cloud and radiation processes. Simulations of climate change, such as global warming effects, are particularly sensitive to how clouds are treated in the models. Scientists would like to undertake a future mission closer to the equator, in the tropical Western Pacific, where cloud formation brings a lot of water vapor from the ocean surface into the atmosphere. The atmosphere bulges out above the warm equator, so scientific flights in this region would call for taking the remotely piloted plane even higher, to 65,000 feet

flies higher and faster and carries a single pilot. The Altus is more maneuverable, controlled remotely, and can stay aloft for an entire day-night cycle.

Stephens called the mission "the beginning of a journey to give us another dimension and view."

The mission, adds Ackerman, is both a scientific exploration and a technology demonstration. "It's like a lot of people building a castle. It happens one brick at a time. After a while, you've got a nice big turret. We're adding to our understanding of how cloud processes work, our understanding of the radiation balance, and our technical ability to address the long-range climate variation problem. We want to be able to say what will happen to the climate 50 years from now, and to say it with confidence."

Will Bolton manages engineering aspects of the overall technical program from Exploratory Systems Technology Dept. 8120. He said measurements of the optical and radiative properties of clouds using airborne radiometers and lidar will contribute to a base of data from which broad trends and a global picture can be extracted over time.

"The deployment was quite successful," Will says. "It marked an excellent collaboration between DOE's ARM-UAV Program, NASA's ERAST Program, General Atomics-Aeronautical Systems, and the US Navy's Pacific Missile Range Facility. This deployment accomplished important operational and scientific objectives and further developed the application of UAVs as a platform for atmospheric and climate-related research."

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NASA's Environmental Research Aircraft and Sensor Technology program, conducted nine science flights with a payload of up to 390 lbs. at 50,000 feet or more. A Twin Otter aircraft flew beneath in stacked formation at 10,000 feet, carrying a specialized lidar (a laser-based detection system) that probed the ice and water content of the sky above. The instruments collected data for about five hours at a time both when the skies were clear and when thick cirrus clouds were present.

Cirrus clouds are considered important in the greenhouse effect, Stephens says, because they are so cold and therefore so effective at retaining thermal radiation in the atmosphere. "We don't know, within a factor of two to three, what the ice content really is in these clouds," he

says. "They're transparent, hard to get to, and very variable."

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"The tropics are where most of the energy is put into the atmosphere," says Bob Ellingson, a professor of meteorology at the University of Maryland and mission scientist for the ARM-UAV program that is staging the science flights in Kauai. "We want to know where it is deposited and moved. There have been very few observations."

There are several advantages to using a remotely piloted, high-altitude aircraft. The aircraft can serve as an instrument platform at remote sites where there are few facilities for studying the climate. The Altus' second-stage turbocharged engine allows it to fly to 65,000 feet, above the part of the atmosphere where most weather occurs. The aircraft complements the ER-2 aircraft, also used to study climate, which

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The four-week mission drew upon contributions of about 25 researchers from three DOE laboratories, a dozen universities, three NASA centers, and four private companies. Key participants include: NASA-Ames Research Center, the University of California at San Diego's Scripps Institution of Oceanography, and Colorado State University, which provided radiometric instruments; Sandia and Lawrence Livermore National Laboratory, which is developing instrumentation for these small, light aircraft; the University of Maryland, which provided the mission scientist; and Pacific Northwest National Laboratory, which provided data management. The Kauai mission was a joint project of the DOE and NASA. NASA's Dryden Flight Research Center in Edwards, Calif., provided the aircraft and funded flight operations.